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(54) Abstract Title
Processing phase information of acoustic signals

(57) A device for processing the phase information of an acoustic signal processes the phase information of a digital speech signal which is expressed as a discrete sum of periodic signals having different frequency components. The device includes a critical bandwidth calculator (100) for calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter, a frequency range setting unit (102) for setting the frequency ranges of local phase changes using critical bandwidths corrected by multiplying the critical bandwidths by a predetermined scaling coefficient α, and a phase significance discriminator (104) for checking whether frequency components adjacent to each frequency are within the frequency range corresponding to the frequency, and discriminating whether the phase of a signal having the frequency component is significant in terms of auditory characteristics. Accordingly, phase components which are significant for auditory perception can be discriminated among the phase components of an acoustic signal. When applied to speech coding, only phase components significant upon auditory perception can be selectively coded among the components of an acoustic signal. Thus, a good quality of sound can be obtained as compared to a method in which the phase information of an acoustic signal is not coded, and the amount of information can be reduced as compared to a method of coding all phase information.

FIG. 1

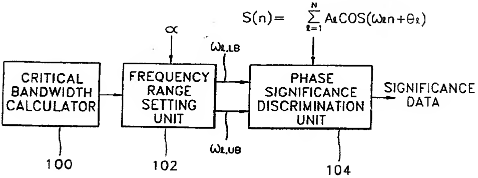

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FIG. 1

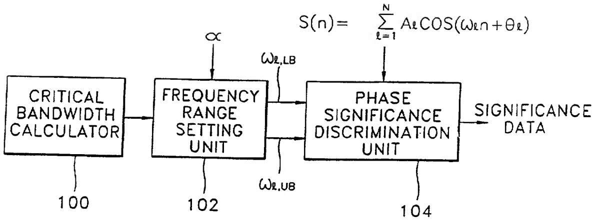

$S(n)= \sum_{\ell=1}^{N} A_\ell COS(\omega_\ell n+\theta_\ell)$
α
$\omega_{\ell,LB}$
$\omega_{\ell,UB}$
CRITICAL BANDWIDTH CALCULATOR
FREQUENCY RANGE SETTING UNIT
PHASE SIGNIFICANCE DISCRIMINATION UNIT
SIGNIFICANCE DATA
100
102
104

FIG. 2

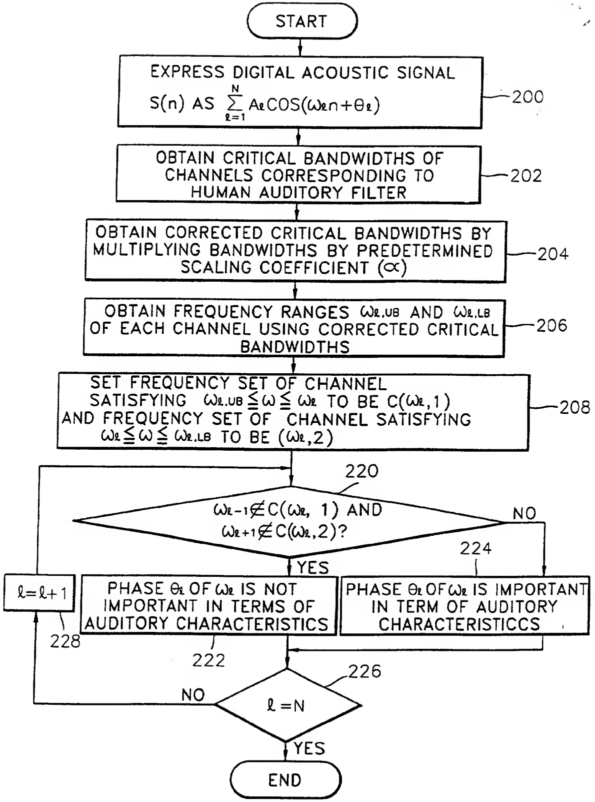

START
EXPRESS DIGITAL ACOUSTIC SIGNAL S(n) AS $\sum_{\ell=1}^{N} A_\ell COS(\omega_\ell n+\theta_\ell)$
200
OBTAIN CRITICAL BANDWIDTHS OF CHANNELS CORRESPONDING TO HUMAN AUDITORY FILTER
202
OBTAIN CORRECTED CRITICAL BANDWIDTHS BY MULTIPLYING BANDWIDTHS BY PREDETERMINED SCALING COEFFICIENT ($\propto$)
204
OBTAIN FREQUENCY RANGES $\omega_{\ell,UB}$ AND $\omega_{\ell,LB}$ OF EACH CHANNEL USING CORRECTED CRITICAL BANDWIDTHS
206
SET FREQUENCY SET OF CHANNEL SATISFYING $\omega_{\ell,UB} \leqq \omega \leqq \omega_\ell$ TO BE $C(\omega_\ell,1)$ AND FREQUENCY SET OF CHANNEL SATISFYING $\omega_\ell \leqq \omega \leqq \omega_{\ell,LB}$ TO BE $(\omega_\ell,2)$
208
220
$\omega_{\ell-1} \not\in C(\omega_\ell, 1)$ AND $\omega_{\ell+1} \not\in C(\omega_\ell,2)$?
NO
YES
224
$\ell=\ell+1$
228
PHASE θ_ℓ OF ω_ℓ IS NOT IMPORTANT IN TERMS OF AUDITORY CHARACTERISTICS
222
PHASE θ_ℓ OF ω_ℓ IS IMPORTANT IN TERM OF AUDITORY CHARACTERISTICCS
226
$\ell=N$
NO
YES
END

FIG. 3A

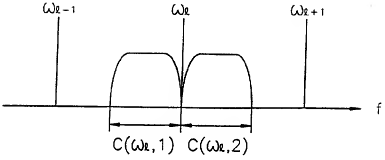


FIG. 3B

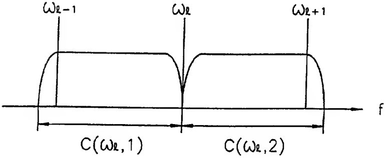


FIG. 4

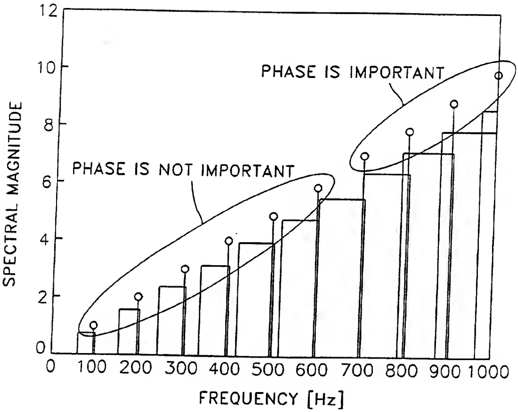

12
10
8
6
4
2
0
0
100
200
300
400
500
600
700
800
900
1000
SPECTRAL MAGNITUDE
FREQUENCY [Hz]
PHASE IS IMPORTANT
PHASE IS NOT IMPORTANT

FIG. 5

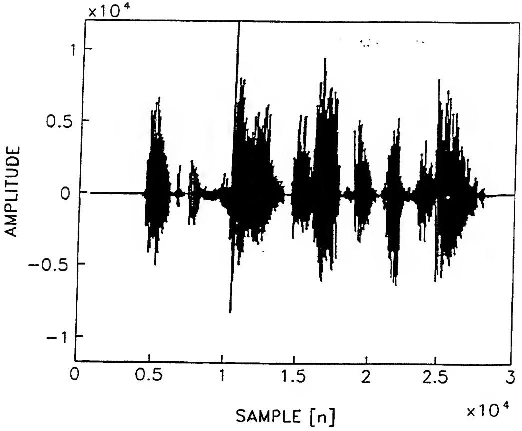


FIG. 6

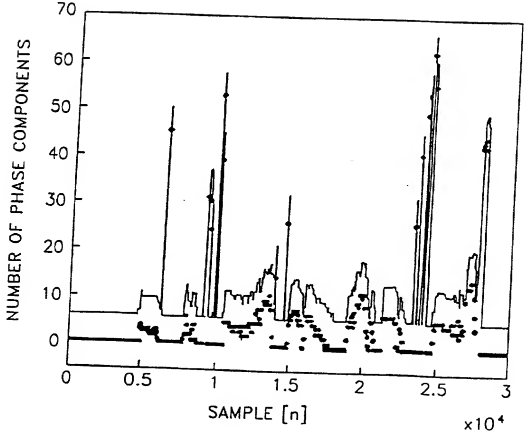
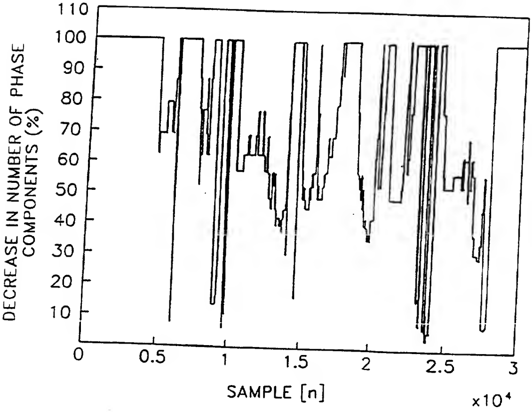

70
60
50
40
30
20
10
0
NUMBER OF PHASE COMPONENTS
0
0.5
1
1.5
2
2.5
3
SAMPLE [n]
x10⁴

FIG. 7



110
100
90
80
70
60
50
40
30
20
10
0
0.5
1
1.5
2
2.5
3
DECREASE IN NUMBER OF PHASE COMPONENTS (%)
SAMPLE [n]
x10⁴

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DEVICE FOR PROCESSING PHASE INFORMATION OF ACOUSTIC SIGNAL AND METHOD THEREOF

The present invention relates to a device for processing the phase information of an acoustic signal and a method thereof, and more particularly, to a device for processing the phase information of an acoustic signal, by which important phase components are discriminated in consideration of human auditory recognition characteristics, and a method thereof.

Research into auditory psychophysics due to a change in the phase of an acoustic signal is in progress, but useful results have not yet been obtained in large numbers. The research results into auditory psychophysics due to a change in the phase of acoustic signals are disclosed by E. Zwicker and H. Fastl, ["Psychoacoustics-Facts and Models", Springer-Verlag, 2nd Eds, 1999], and B.C.J.Moore, ["Introduction to the Psychology of Hearing", Academic Press, 4th Eds., 1997]. According to these documents, the cochlea of the internal ear among hearing organs can be modeled as a filter bank. The filter bank includes band pass filters, and the passband of each filter can be estimated when the central frequency of the filter is given. Signal processing within a human ear has been known as multi-channel signal processing preformed in units of each critical band of the filter.

When a phase change in a signal is considered from this standpoint, a local phase change denotes a change in the relative phase relationship between signal components which exist within the same critical band (i.e., within the same channel). A global phase change denotes that the phase relationship between channels varies while the relative phase relationship between signal components within the same critical band is being kept. The human ear is dull to global phase changes and somewhat sensitive to local phase changes, which is not completely theorized but known in relation to auditory psychophysics with respect to phase. This is disclosed by R.D. Patterson, ["A Pulse Ribbon Model of Monaural Phase Perception", J. Acoust. Soc. Am., Vol. 82, No. 5, pp. 1560-1586, 1987]; and M.R. Schroeder, ["New Results Concerning Monaural Phase Sensitivity", J.Acoust. Soc. Am, Vol. 31, p.1579, 1959].

Also, phase information processing in a harmonic speech system is disclosed by R.J. MacAulary and T.F. Quatieri, "Sinusoidal Coding in Speech Coding and Synthesis", W.B. Kleijn and K.K. Palivwal Eds, Elsevier, pp. 121-173, 1998; J.S. Marques and L.B. Almeida, "Sinusoidal Modeling of Voiced and Unvoiced Speech", in Proc. ICASSP, pp. 203-206, 1983; and J.S. Marques, L.B. Almeida, and J.M. Tribolet, "Harmonic coding at 4.8kb/s", in Proc. ICASSP, pp. 17-20, 1990. According to these documents, a harmonic speech coding system can be used to express the excitation signal of speech using the following Equation 1:

$$e(n)=\sum_{k=1}^{K} A_k \cos(k\omega_0 n+\theta_k) \qquad \ldots(1)$$

wherein ω_0 denotes a fundamental frequency, A_k denotes the spectral magnitude of harmonics, and θ_k denotes the phase of harmonics. The excitation signal is used as the input to a filter which has been modeled by the spectral envelope of speech, to thereby finally obtain an acoustic signal. Thus, in a speech coding system, spectrum envelope filter coefficients, the spectral magnitude A_k, the fundamental frequency ω_0, and the phase of harmonics (θ_k) are quantized and transmitted, and acoustic signals are synthesized using the received parameters. In present harmonic speech coding systems, the spectrum phase information θ_k is relatively neglected compared to the spectral magnitude information A_k of a signal, and a method in which a transmission system does not send the phase information of an acoustic signal, but a reception system applies an arbitrary phase using the condition that the phase of an acoustic signal continuously changes, is generally used.

However, an acoustic signal synthesized by the conventional method does not provide a satisfactory quality of sound. Also, when phase information is completely coded to solve this problem, the amount of information increases too much.

The present invention seeks to provide an acoustic signal phase information processing device and method, in which important phase components are discriminated in consideration of human auditory characteristics to selectively code or synthesize the phase components of an acoustic signal.

According to a first aspect of the present invention, there is provided a device for processing the phase information of a digital speech signal which is expressed as a discrete sum of periodic signals having different frequency components comprising a critical bandwidth calculator for calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter a frequency range

setting unit for setting the frequency ranges of local phase changes using critical bandwidths corrected by multiplying the critical bandwidths by a predetermined scaling coefficient, and a phase significance discriminator for checking whether frequency components adjacent to each frequency are within the frequency range corresponding to the frequency, and discriminating whether the phase of a signal having the frequency component is significant in terms of auditory characteristics.

Preferably, the device further includes an acoustic signal transformer for transforming an acoustic signal into the discrete sum of periodic signals having different frequency components. Also, it is preferable that the scaling coefficient is smaller than 1. Preferably, the phase significance discriminator obtains an assembly of frequencies having phases that are significant in terms of auditory characteristics.

According to a second aspect of the present invention, there is provided a device for processing the phase components of an acoustic signal comprising an acoustic signal transformer for transforming an acoustic signal into $s(n)=\sum_{l=1}^{L} A_l \cos(\omega_l n+\theta_l)$, wherein L is an integer greater than 1, A_l, ω_l, and θ_l denote the spectral magnitude, frequency, and phase of an l-th periodic signal, respectively, and $\omega_1 < \omega_2 < \ldots < \omega_L$; a critical bandwidth calculator for calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter; a frequency range setting unit for obtaining critical bandwidths $\omega_{L,UB}$ and $\omega_{l,LB}$ corrected by multiplying the critical bandwidths by a predetermined scaling coefficient, and setting a frequency set of a channel satisfying the condition of $\omega_{l,LB} \leq \omega \leq \omega_l$ with the frequency ω_l set as an upper bound, to be $C(\omega_l,1)$, and setting a frequency set of a channel satisfying the condition of $\omega_l \leq \omega \leq \omega_{l,UB}$ with the frequency ω_l set as a lower bound, to be $C(\omega_l,2)$; and a phase significance discriminator for discriminating whether the conditions of $\omega_{l-1} \notin C(\omega_l,1)$ and $\omega_{l+1} \notin C(\omega_l,2)$ are satisfied with respect to ω_l, and outputting significance data representing that the phase θ_l of the frequency ω_l is not significant in terms of auditory characteristics, if the conditions are satisfied, and otherwise, outputting significance data representing that the phase θ_l of the frequency ω_l is significant in terms of auditory characteristics.

According to a third aspect of the present invention, there is provided a method of processing the phase components of an acoustic signal comprising the steps of (a) expressing an acoustic signal as a discrete sum of periodic signals having different frequency components, (b) calculating the critical bandwidth of each frequency according

to the bandwidth characteristics of a human's auditory filter, (c) obtaining corrected critical bandwidths by multiplying the critical bandwidths by a predetermined scaling coefficient, (d) setting the frequency ranges of local phase changes using the critical bandwidths corrected in step (c), and (e) checking whether frequency components adjacent to each frequency are within the frequency range corresponding to the frequency, and discriminating whether the phase of a signal having the frequency component is significant in terms of auditory characteristics.

According to a fourth aspect of the present invention, there is provided a method of processing the phase components of an acoustic signal comprising (a) expressing an acoustic signal as $s(n)=\sum_{l=1}^{L} A_l \cos(\omega_l n+\theta_l)$, wherein L is an integer greater than 1, A_l, ω_l, and θ_l denote the spectral magnitude, frequency, and phase of an l-th periodic signal, respectively, and $\omega_1 < \omega_2 < \ldots < \omega_L$; (b) calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter; (c) obtaining critical bandwidths $\omega_{l,UB}$ and $\omega_{l,LB}$ corrected by multiplying the critical bandwidths by a predetermined scaling coefficient; (d) setting the frequency ω_l as an upper bound and setting a frequency set of a channel satisfying the condition of $\omega_{l,LB} \le \omega \le \omega_l$ to be $C(\omega_l, 1)$; (e) setting the frequency ω_l as a lower bound and setting the frequency assembly of a channel satisfying the condition of $\omega_l \le \omega \le \omega_{l,UB}$, to be $C(\omega_l, 2)$; and (e-1) determining the phase θ_l of the frequency ω_l as a phase which is not significant in terms of auditory characteristics, if the conditions are satisfied in step (e); and (e-2) determining the phase θ_l of the frequency ωl as a phase which is significant in terms of auditory characteristics, if the conditions are not satisfied in step (e); (f) determining whether I is L, and concluding the process if the I is L, and otherwise, increasing the I by one and returning to the step (e).

Examples of the present invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a block diagram illustrating the structure of a device for processing the phase information of an acoustic signal, according to an embodiment of the present invention;

Figure 2 is a flowchart illustrating a method of processing the phase information of an acoustic signal, according to an embodiment of the present invention;

Figures 3A and 3B are views for illustrating a process for discriminating the phase importance in the device according to the present invention;

Figure 4 is a graph showing a process for discriminating the phase importance with respect to a harmonic signal in the device according to the present invention;

Figure 5 is a waveform diagram illustrating the acoustic waveforms of a woman's speech in an NTT Advanced Technology Corporation (NATC: registered trademark) database; and

Figures 6 and 7 are graphs for explaining a reduction in phase transmission amount with respect to the speech of Figure 5.

Referring to Figures 1 and 2, a device for processing the phase information of an acoustic signal according to the present invention includes a critical bandwidth calculator 100, a frequency range setting unit 102, and a phase significance discrimination unit 104.

In the operation of the device, first, it is assumed that a digital signal to be synthesized can be expressed as in the following Equation 2:

$$s(n)=\sum_{l=1}^{L} A_l \cos(\omega_l n+\theta_l) \qquad \ldots(2)$$

wherein L is an integer greater than 1, A_l denotes the amplitude of an l-th periodic signal, ω_l denotes the frequency thereof, θ_l denotes the phase thereof, and $\omega_1 < \omega_2 < \ldots < \omega_L$, in step 200. The digital signal is expressed as a line spectrum in each ω_l in the frequency domain. A transformer (not shown) for transforming an acoustic signal into the discrete sum of periodic signals having different frequencies, many be further included as necessary.

The critical bandwidth calculator 100 calculates the critical bandwidths of channels corresponding to a human's auditory filter according to the bandwidth characteristics of the human's auditory filter, in step 202. For example, an equivalent rectangular bandwidth (ERB) or a bark scale can be applied as the bandwidth characteristics of the human's auditory filter.

The frequency range setting unit 102 obtains corrected critical bandwidths by multiplying the critical bandwidths by a predetermined scaling coefficient (α), in step 204. The frequency range setting unit 102 also sets the frequency ranges $\omega_{l,\,UB}$ and $\omega_{l,\,LB}$ of a local phase change using the corrected critical bandwidths, in step 206. In the present embodiment, it is assumed that the scaling coefficient (α) is 1, and the frequency ranges $\omega_{l,\,UB}$ and $\omega_{l,\,LB}$ are the same as the corrected critical bandwidths. It is preferable that the scaling coefficient (α) can be controlled by auditory experiments, and is smaller than 1.

Also, the frequency ranges $\omega_{l,UB}$ and $\omega_{l,LB}$ can also be controlled to some extent by the auditory experiments.

The frequency range setting unit 102 also sets a frequency set of a channel satisfying the condition of $\omega_{l,LB} \leq \omega \leq \omega_l$, wherein the frequency ω_l is set as an upper bound, to be $C(\omega_l, 1)$ and sets a frequency set of a channel satisfying the condition of $\omega_l \leq \omega \leq \omega_{l,UB}$, wherein the frequency ω_l is set as a lower bound, to be $C(\omega_l, 2)$, in step 208.

In step 220, the phase significance discrimination unit 104 discriminates whether ω_l satisfies the conditions shown in the following Inequality 3:

$$\omega_{l-1} \notin C(\omega_l, 1) \; and \; \omega_{l+1} \notin C(\omega_l, 2) \qquad \ldots(3)$$

That is, the phase significance discrimination unit 104 determines the phase θ_l of the frequency ω_l as a phase that is not significant in terms of auditory characteristics, if the conditions shown in Inequality 3 are satisfied, in step 222. Otherwise, the phase significance discrimination unit 104 determines the phase θ_l of the frequency ω_l as a phase that is significant in terms of auditory characteristics, in step 224. That is, the phase θ_l of the frequency ω_l satisfying the conditions shown in Inequality 3 is determined as a phase which is not significant in terms of auditory characteristics. Thus, the phase significance discrimination unit 104 discriminates whether the conditions of $\omega_{l-1} \notin C(\omega_l, 1)$ and $\omega_{l+1} \notin C(\omega_l, 2)$ are satisfied with respect to ω_l. If the conditions shown in Inequality 3 are satisfied, the phase significance discrimination unit 104 outputs phase significance data representing that the phase θ_l of the frequency ω_l is not significant in terms of auditory characteristics, and otherwise, it outputs phase significance data representing that the phase θ_l of the frequency ω_l is significant in terms of auditory characteristics.

Also, the phase significance discrimination unit 104 checks if a parameter I has reached L, in step 226. If the parameter I has reached N, the discrimination process is concluded. Otherwise, the parameter I is increased by 1, and then the steps 220, 222 and 224 are repeated. Therefore, discrimination with respect to the phase of each frequency component is performed.

Figures 3A and 3B are views for explaining a process for discriminating the phase significance, wherein Figure 3A refers to when Inequality 3 is satisfied and Figure 3B refers to when Inequality 3 is not satisfied.

Referring to Figure 3A,ω_l satisfies the conditions of $\omega_{l-1} \notin C(\omega_l,1)$ and $\omega_{l+1} \notin C(\omega_l,2)$. As described above, when ω_l satisfies the conditions shown in Inequality 3, only the frequency component of the frequency ω_l lies within a channel. Thus, even if the phase θ_l is synthesized or coded with an arbitrary phase value, the relative phase relationship within a channel is maintained, and does not affect other channels. Consequently, even if a signal having a different phase to the phase of the original signal is applied, it is very difficult to audibly perceive the difference.

Referring to Figure 3B, ω_l satisfies the conditions of $\omega_{l-1} \in C(\omega_l,1)$ and $\omega_{l+1} \in C(\omega_l,2)$, so the conditions shown in Inequality 3 are not satisfied. As described above, when ω_l does not satisfy the conditions shown in Inequality 3, other frequency components mix within a channel. A phase change in this frequency causes a change in the relative phase relationship. Thus, a phase change greater than or equal to a certain amount can be audibly perceived. Consequently, if a corresponding frequency is synthesized with an arbitrary phase, a difference can be audibly perceived.

Figure 4 is graph showing a process for discriminating the phase significance with respect to a harmonic signal in the device according to the present invention. In Figure 4, the horizontal axis represents the frequency of a harmonic signal in Hz, and the vertical axis represents the amplitude of the harmonic signal.

Generally, in view of human auditory characteristics, the critical bandwidth becomes wider as the frequency increases. Thus, a frequency component corresponding to a frequency of 100Hz to 600Hz is not included within two different critical bandwidths. Thus, the phase of this frequency is not important in terms of human auditory characteristics as described above with reference to Figure 3A. On the other hand, a frequency component corresponding to a frequency of 700Hz to 1000Hz can be included within two different critical bandwidths. Thus, a phase change in this frequency can be perceived by the human ear as described above with reference to Figure 3B.

This device and method for processing the phase information of an acoustic signal can be applied to speech coding. That is, upon coding, only phase components which are significant in terms of auditory characteristics are coded or synthesized. Upon decoding, even if uncoded phase components, that is, phase components that are not significant in terms of auditory characteristics, are synthesized by applying an arbitrary value, the difference can hardly be audibly perceived because of the human auditory characteristics. Therefore, phase components are transmitted or synthesized by applying the device and

method for processing the phase information of an acoustic signal according to the present invention, so that the quality of sound can be improved. Also, the amount of phase information required can be reduced.

Figure 5 is a waveform diagram illustrating the acoustic waveform of a woman's speech in an NTT Advanced Technology Corporation (NATC: registered trademark) database. Figure 6 shows a comparison of the number of phase components to be transmitted when a method according to the present invention is applied to the speech of Figure 5 and when a conventional method is applied to the speech of Figure 5, according to the lapse of time. Referring to Figure 6, when the conventional method is applied, the number of phase components to be transmitted according to the lapse of time is indicated by an unbroken line. When the method of the present invention is applied, frequency components, which are included one by one in an auditory channel, exist in a predetermined range of a low frequency, and may not be transmitted. Thus, the number of phase components to be transmitted is reduced. The number of phase components to be transmitted according to the present invention is indicated by a dotted line. Non-transmitted phase components are arbitrarily synthesized on the basis of consecutive phase change conditions. Here, as the results of an ERB experiment, there is no difference in auditory perception between speech synthesized using the phase components indicated by the unbroken line which transmitted through an auditory channel, and speech synthesized using only the phase components indicated by a dotted line which are transmitted therethrough. Figure 7 shows percent decrease in the number of phase components by applying the present invention.

As described above, in the device and method of processing the phase information of an acoustic signal according to the present invention, significant phase components in terms of auditory perception can be discriminated among the components of an acoustic signal.

Also, when the device and method of processing the phase information of an acoustic signal according to the present invention are applied to speech coding, only the significant phase components in terms of auditory perception are selectively coded among the components of an acoustic signal. Thus, a good quality of sound can be obtained as compared to a method in which the phase information of an acoustic signal is not coded, and the amount of information can be reduced as compared to a method of coding all phase information. Also, it will be understood by one of ordinary skill in the art that

these effects can be equally obtained from the fields of speech synthesis and speech transmission.

Claims

1. A device for processing the phase information of a digital speech signal which is expressed as a discrete sum of periodic signals having different frequency components, comprising:

a critical bandwidth calculator for calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter;

a frequency range setting unit for setting the frequency ranges of local phase changes using critical bandwidths corrected by multiplying the critical bandwidths by a predetermined scaling coefficient; and

a phase significance discriminator for checking whether frequency components adjacent to each frequency are within the frequency range corresponding to the frequency, and discriminating whether the phase of a signal having the frequency component is significant in terms of auditory characteristics.

2. A device according to claim 1, further comprising an acoustic signal transformer for transforming an acoustic signal into the discrete sum of periodic signals having different frequency components.

3. A device according to claim 1 or 2, wherein the scaling coefficient is smaller than 1.

4. A device according to claim 1, 2 or 3, wherein the phase significance discriminator obtains an assembly of frequencies having phases that are significant in terms of auditory characteristics.

5. A device for processing the phase components of an acoustic signal, comprising:

an acoustic signal transformer for transforming an acoustic signal into $s(n)=\sum_{l=1}^{L} A_l \cos(\omega_l n+\theta_l)$, wherein L is an integer greater than 1, A_l, ω_l, and θ_l denote

the spectral magnitude, frequency, and phase of an l-th periodic signal, respectively, and $\omega_1 < \omega_2 < \ldots < \omega_L$;

a critical bandwidth calculator for calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter;

a frequency range setting unit for obtaining critical bandwidths $\omega_{L,UB}$ and $\omega_{l,LB}$ corrected by multiplying the critical bandwidths by a predetermined scaling coefficient, and setting a frequency set of a channel satisfying the condition of $\omega_{l,LB} \leq \omega \leq \omega_l$ with the frequency ω_l set as an upper bound, to be $C(\omega_l,1)$, and setting a frequency set of a channel satisfying the condition of $\omega_l \leq \omega \leq \omega_{l,UB}$ with the frequency ω_l set as a lower bound, to be $C(\omega_l,2)$; and

a phase significance discriminator for discriminating whether the conditions of $\omega_{l-1} \notin C(\omega_l,1)$ and $\omega_{l+1} \notin C(\omega_l,2)$ are satisfied with respect to ω_l, and outputting significance data representing that the phase θ_l of the frequency ω_l is not significant in terms of auditory characteristics, if the conditions are satisfied, and otherwise, outputting significance data representing that the phase θ_l of the frequency ω_l is significant in terms of auditory characteristics.

6. A method of processing the phase components of an acoustic signal, comprising the steps of:

(a) expressing an acoustic signal as a discrete sum of periodic signals having different frequency components;

(b) calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter;

(c) obtaining corrected critical bandwidths by multiplying the critical bandwidths by a predetermined scaling coefficient;

(d) setting the frequency ranges of local phase changes using the critical bandwidths corrected in step (c); and

(e) checking whether frequency components adjacent to each frequency are within the frequency range corresponding to the frequency, and discriminating whether the phase of a signal having the frequency component is significant in terms of auditory characteristics.

7. A method according to claim 6, wherein the scaling coefficient is smaller than 1.

8. A method of processing the phase components of an acoustic signal, comprising the steps of:

(a) expressing an acoustic signal as $s(n)=\sum_{l=1}^{L} A_l \cos(\omega_l n+\theta_l)$, wherein L is an integer greater than 1, A_l, ω_l, and θ_l denote the spectral magnitude, frequency, and phase of an l-th periodic signal, respectively, and $\omega_l < \omega_2 < \ldots < \omega_L$;

(b) calculating the critical bandwidth of each frequency according to the bandwidth characteristics of a human's auditory filter;

(c) obtaining critical bandwidths $\omega_{l,\ UB}$ and $\omega_{l,\ LB}$ corrected by multiplying the critical bandwidths by a predetermined scaling coefficient;

(d) setting the frequency ω_l as an upper bound and setting a frequency set of a channel satisfying the condition of $\omega_{l,\ LB} \leq \omega \leq \omega_l$ to be $C(\omega_l, 1)$;

(e) setting the frequency ω_l as a lower bound and setting the frequency assembly of a channel satisfying the condition of $\omega_l \leq \omega \leq \omega_{l,UB}$, to be $C(\omega_l, 2)$; and

(e-1) determining the phase θ_l of the frequency ω_l as a phase which is not significant in terms of auditory characteristics, if the conditions are satisfied in step (e); and

(e-2) determining the phase θ_l of the frequency ωI as a phase which is significant in terms of auditory characteristics, if the conditions are not satisfied in step (e);

(f) determining whether I is L, and concluding the process if the I is L, and otherwise, increasing the I by one and returning to the step (e).

9. A device for processing the phase information of a digital speech signal as herein described with reference to the accompanying drawings.

10. A device for processing the phase components of an acoustic signal as herein described with reference to the accompanying drawings.

11. A method of processing the phase components of an acoustic signal as herein described with reference to the accompanying drawings.

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Application No:	GB 0010945.4	**Examiner:**	Martyn Dixon
Claims searched:	all	**Date of search:**	20 November 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4R (RPBE,RPV,RPVA,RPX); H4P (PDCFT)

Int Cl (Ed.7): G10L; H04B (1/66)

Other: Online: EPODOC,WPI,JAPIO,INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	US 5388181 A	(Anderson *et al*) see especially col 8, line 55 to col 9, line 59 and col 14, lines 63 *et seq*	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		